Select the Optimal Power Management IC

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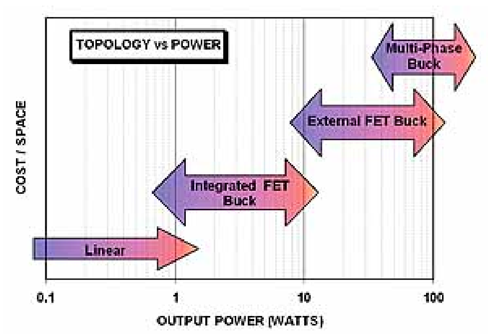
Managing power is a critical requirement for all electronic equipment from notebooks to PDAs to storage peripherals. Power management ICs can optimize power usage to match the constantly changing demands of whatever task the device is carrying out. There are several important criteria to consider when selecting the best IC for an application.

Three important criteria are topology, efficiency and transient performance. The topology is usually dictated by the input and output voltage and current. The efficiency can be increased, and transient response can be fast using complex power management systems. But these cost more and may require more space than simple, less efficient systems. To make the optimal selection, it is important to consider the efficiency and transient response of various types of regulators.

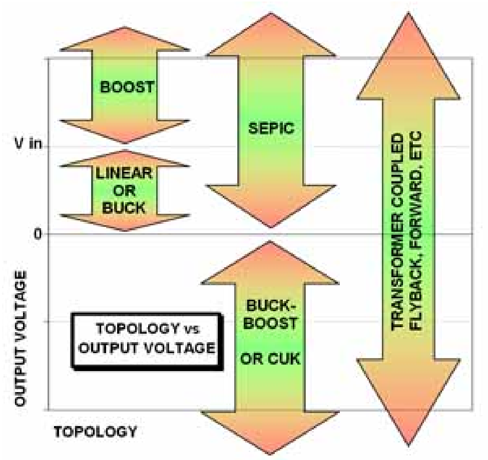
Topologies and Load Power



Despite the broad, often bewildering array of power supply topologies available, selecting a good one for your application can be a relatively simple process of elimination. First, consider input and output voltage and current. If the output voltage is lower than the input, you will probably want a linear regulator or a buck regulator. Other topologies can provide a wide range of output voltages and isolation, and these are discussed below. After choosing a topology such as the buck regulator, there are choices that affect efficiency and transient response.
For extremely low load power such as a voltage reference, it is acceptable to use a shunt regulator with efficiency less than 50 percent. Linear regulators, also known as series pass, LDO or Low Drop Out regulators, are cheap and easy to use, but they also have low efficiency. Low cost linear regulators are good for loads up to 1W, and they are available in packages from the 0.25W SOT23 to the 1W DPAKII. A typical application for a linear regulator is supplying 3.3V and 300 mA from a 5V input. Most systems that provide several supply voltages use some linear regulators where the load and waste power are less than 1W. Also, many power management ICs bundle switching regulators and linear regulators in one IC, offering the benefits

of integration.

For load power above 1W, switching regulators are usually smallest and lowest in cost. Switching regulator ICs with integrated FETs are available for loads in the range of 0.1A to 5A (some higher). External FETs take more room, but they may offer lower total cost for loads above 5A. At high load currents, synchronous rectifier FETs (synch FETs) are used. Regulator ICs drive a FET in parallel with the buck regulator's diode to reduce wasted power. With two DPAKII FETs, a synchronous buck regulator can deliver over 100W (>30A at 3.3V). For example, the ISL6269 includes the control system and drivers for a high side NFET and a synch FET. For very high load current such as the CPU in a PC (50A to 120A at 1V), multi-phase buck regulators are used.



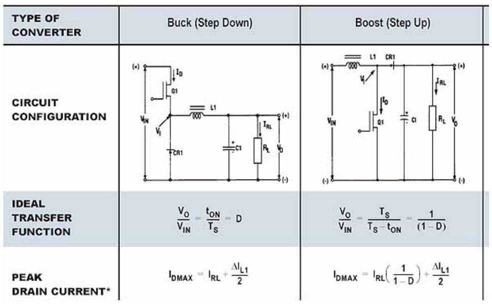
Multi-phase buck regulators place several switches and inductors in parallel, sourcing current to a set of output capacitors. The multiple switches operate at the same frequency but out of phase. Efficiency and response to load transients are improved because the parasitic source impedances (inductor L, DCR and FET RDSon) are in parallel. The negative aspect of multi-phase is cost and space for more FETs, drivers and inductors. However, for load currents >30A, multiphase buck regulators can be the smallest and the lowest in cost.

Other Topologies

If the required output voltage is always lower than your input voltage, use a step-down topology like a linear or buck regulator. If the output is always higher than the input voltage, choose a step-up topology like a boost converter. If the input voltage is positive but a negative rail is required, use a buck-boost or a Cuk converter. If the input voltage may be higher or lower than the output voltage, use a step down/up converter like the Sepic converter. An example of an application that requires "step down/up" is a 3.3V output derived from a single Lithium Ion battery with voltage ranges from 4.2V max. to 2.5V min. Transformer coupled topologies like the forward or flyback can produce multiple outputs at a wide range of voltages and they provide isolation.

If the design requires isolation from the AC mains, a transformer-coupled topology is required such as the forward, flyback and others. “Off-line” supplies, which receive input power from the AC mains, need to be isolated to protect the user from being shocked. AC adapter design is another option — there are a variety of ICs developed specifically for isolated supplies.

Complex power systems require many output voltages and several regulators mentioned above. Many ICs contain three, four or more power supply controllers. One good representative choice for many designs is a device with two independent buck controllers accompanied by an internal LDO.



TYPE OF CONVERTER	Buck (Step Down)	Boost (Step Up)
CIRCUIT CONFIGURATION		
IDEAL TRANSFER FUNCTION	$\frac{V_O}{V_{IN}} = \frac{t_{ON}}{T_S} = D$	$\frac{V_O}{V_{IN}} = \frac{T_S}{T_S - t_{ON}} = \frac{1}{(1-D)}$
PEAK DRAIN CURRENT*	$I_{DMAX} = I_{RL} + \frac{\Delta I_{L1}}{2}$	$I_{DMAX} = I_{RL}\left(\frac{1}{1-D}\right) + \frac{\Delta I_{L1}}{2}$

A comparison of buck and boost converters characteristics: circuit configuration, ideal transfer function and peak drain current.

Efficiency

It is also useful to determine the level of efficiency desired in the application. Low efficiency reduces maximum output power or battery life. Input power is limited by the power source such as the AC adapter or battery. Higher efficiency may allow for a smaller adapter. Input power in standby mode may be limited by Energy Star standards. Low efficiency may result in thermal problems. A 100W supply that is 90 percent efficient dissipates approximately 10W in the supply which can be too hot for a confined space. In this case, increasing efficiency to 95 percent reduces waste power by half. The following is a rough ranking of efficiency from low to high:

1. Shunt regulators
2. Linear regulators
3. Standard buck regulators
4. Synchronous buck regulators
5. Multiphase, synchronous buck regulators
6. Exotic topologies with zero voltage and or zero current switching

The synchronous buck regulator is the ‘sweet spot’ in this list because it is only slightly more complex than a standard buck, and it is significantly more efficient. Other topologies have a similar ranking where efficiency can be increased with more complex circuits, higher cost and more space.

Transient Response

Sudden changes in load current can make the output voltage sag below its minimum or overshoot to excessive voltages. The response depends on the IC’s control system and the buck regulator’s output LC filter. IC manufacturers will give typical transient response plots. Transient response can be improved with smaller output. Smaller inductors give faster response but higher peak-to-peak currents that hurt efficiency. High switching frequency allows the use of smaller inductors but increases switching losses. High switching losses make efficiency lower at light loads. Conversely, lower switching frequency can give better efficiency but slower response to load transients. Some regulators have variable frequency control systems to get the best trade-offs.

Power management ICs also offer a wide range of features such as over-current and over-voltage protection, thermal shut down, input under-voltage lock out and many more.

Bob Lyle joined Intersil in 2002 as a staff applications engineer for CPU core power and battery chargers. Before joining Intersil, he designed power electronics at Virata, Philips, ITT and NASA. He received a BSEE from the University of Tennessee in 1980. For more information, contact Intersil, 1001 Murphy Ranch Road, Milpitas, CA 95035; (408) 432-8888; www.intersil.com/power/ [1]

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